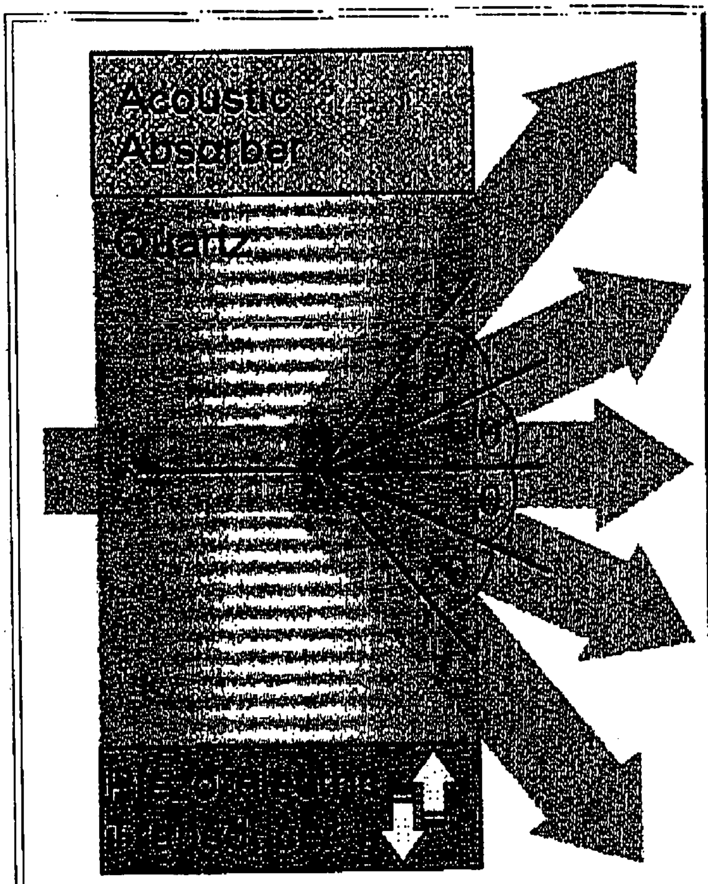
Exhibit A

Acousto-optic modulator

From Wikipedia, the free encyclopedia.

An **acousto-optic modulator** (AOM) uses the acousto-optic effect to diffract and shift the freqency of light using sound waves(usually at radio-frequency). They are used in lasers for Q-switching, telecommunications for signal modulation, and in spectroscopy for frequency control. A piezo-electric transducer is attached to a material such as glass. An oscillating electric signal drives the tranducer to vibrate, which creates sound waves in the glass. These can be thought of as moving periodic planes of expansion and compression that change the index of refraction. Incoming light scatters (see Brillouin scattering) off the resulting periodic index modulation and interference occurs similar to in Bragg diffraction. The interaction can be thought of as four-wave mixing between phonons and photons. The properties of the light exiting the AOM can be controlled in four ways:



An acousto-optic modulator (AOM) consists of a piezo-electric transducer which creates sound waves in a material like glass or quartz. A light beam is diffracted into several orders. By vibrating the material with a pure sinusoid and tilting the AOM so the light is reflected from the flat sound waves into the first diffraction order, up to 90% deflection efficiency can be achieved.

1. Deflection

A diffracted beam emerges at an angle θ that depends on the wavelength of the light λ relative to the wavelength of the sound Λ

$$sin\theta = \left(\frac{m\lambda}{2\Lambda}\right)$$

where $m = ...-2,-1,0,1,2,...$ is the order of diffraction. The angular deflection can range from 50 to 5000 beam widths (the number of resolvable spots). Consequently, the deflection is typically limited to tens of milliradians.

2. Intensity

The amount of light in diffracted by the sound wave depends on the intensity of the sound. Hence, the intensity of the sound can be used to modulate the intensity of the light in the diffracted beam.

3. Frequency

One difference from Bragg diffraction is that the light is scattering from moving planes. A consequence of this is the frequency of the diffracted beam f in order m will be doppler-shifted by an amount equal to the frequency of the sound wave F.

$$f \rightarrow f + mF$$

This frequency shift is also required by the fact that energy and momentum (of the photons and phonons) are conserved in the process. The maximum possible frequency shift is typically limited to tens of megahertz.

4. Phase

In addition, the phase of the diffracted beam will also be shifted by the phase of the sound wave. The phase can be changed by an abritrary amount.

Acosto-optic modulators are much faster then typical mechanical devices such as tiltable mirrors. The time it takes an AOM to shift the exiting beam in is roughly limited to the transit time of the sound wave across the beam (typically 5-100 microseconds). When faster control is necessary electro-optic modulators are used. However, these require very high voltages (e.g. 10 kiloVolt), whereas AOMs offer more deflection range, simple design, and low power consumption (<3 Watts).

Retrieved from "http://en.wikipedia.org/wiki/Acousto-optic_modulator"

Categories: Optics
